

HOW TO USE TECHNOLOGY AS AN EFFECTIVE OUTREACH INSTRUMENT

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ABSTRACT

Science is a study of the natural world and technology is a study of how humans modify that world. We discuss how we can use technology as means to reach and educate the public through technology transfer and commercialization, and the international technology education and standards provided by the International Technology Education Association (ITEA). We will also present highlights of the NASA Microgravity Research Outreach Program, and how NASA has participated in the development of the newly released "Standards for Technological Literacy: Content for the Study of Technology", as endorsed by the National Research Council (NRC). Also presented will be an overview of the NASA/ITEA Microgravity Teacher's Guide for Technology Education.

BASIC SCIENCE, APPLIED RESEARCH, AND TECHNOLOGY

Of all the forms of research, the most misunderstood by the public, the scientists say, is basic science. It is the kind of research that built the knowledge base underlying all practical benefits that society has realized from technology. And yet, it battles repeated challenges as a luxury that the world can no longer afford⁽³⁾.

The Clinton administration's national science policy, announced in August 1994⁽¹⁾, rejects the notion of basic and applied science being two competing branches of science and, in a statement that many scientists agree with, says that the two areas of research are interdependent parts of an "ecosystem" along with technology. However, the support for basic research and space science during last decade has been declining. Why? Probably, because basic research and space science have not captured enough of the public attention and support.

Fortunately, this situation may change soon. In the United States, President Clinton, in his speech at the California Institute of Technology on January 21, 2000, announced a proposal to increase the budget for basic science. Saying that the scientists have a unique role to play, and special responsibilities to fulfill, in shaping the course of the 21st century, Clinton unveiled comprehensive new budget proposals for boosting federal support of science and technology. "Big ideas in science matter" Clinton said. "Once you make a big breakthrough, thousands and thousands of things follow that have immense practical significance"

The President said that both government officials and the scientific community need to do a better job of explaining this crucial connection to the public. He called for intensified efforts to raise public awareness about how federal support for basic research and its spin-offs has fueled national prosperity, has contributed greatly to our current climate of opportunity and, "broadly stated, will allow us to lead longer and healthier lives."

The President made a very profound statement, that we believe applies to people of all nations. "It is our responsibility to open the world of science to more of our fellow citizens; to help them understand the great questions science is seeking to answer and to help them see how those answers will actually affect their lives and their children's lives in profoundly important and positive ways."

EXAMPLES OF PUBLIC OUTREACH THROUGH TECHNOLOGY TRANSFER AND COMMERCIALIZATION AT NASA

When you open NASA's website at <http://www.nasa.gov> and look up the Administrator's Welcome letter, you will see a statement that accurately summarizes many of the NASA outreach activities. "NASA is deeply committed to spreading the unique knowledge that flows from its aeronautics and space research. This commitment grows from the Agency's unique, original congressional mandate to provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof. Throughout the past three-and-a-half decades, NASA has accomplished this basic assignment through printed press releases, radio programming, television shows educational materials and, more recently, the fax machine. The futuristic capabilities of the Internet promise to expand this outreach exponentially, and we are tremendously excited by the possibilities. Now or in the near future, you will be able to download the latest imagery from the Hubble Space Telescope, read about recent uses of NASA-developed technology by private industry, watch a short video of the first human landing on the Moon or view the latest microgravity science experiment underway aboard the planned international Space Station."

Perhaps, one of the most effective ways to reach the public is accomplished by showing to the society the practical benefits resulting from space research and technology development. NASA's technology webpage, at <http://nasatechnology.nasa.gov>, offers abundance of information, including images, on this topic. The NASA Technology Inventory -- a database of NASA's current investments in technology development is one of the examples. The inventory includes descriptions of technology tasks and the linkage between the tasks and NASA Enterprise strategic goals. The inventory is web-based and supports keyword searches. For the purposes of this inventory data base, technology is defined as the practical application of knowledge to create the capability to do something entirely new or in an entirely new way. This can be contrasted to "scientific research," which encompasses the discovery of new knowledge from which new technology is derived, and engineering, which uses technology derived from this knowledge to solve specific technical problems. When investments are made in a particular technology, it begins to mature - a process of testing and analysis that progressively reduces the programmatic risk of selecting that technology for an application and increases the readiness of that technology for use in a mission. Technology may be described in terms of maturity within a scale of Technology Readiness Levels, that reflect the extent to which the technology has been proven in a realistic situation. This definition carries the message that without basic science to enlarge the body of knowledge, science cannot continue to produce practical benefits and without new technologies neither basic nor applied science can progress. This is the important message we need to convey to the public. A public version of the NASA Technology Inventory is planned this year. NASA Commercial Technology section of the NASA technology webpage provides the public with access to information on many commercial resources. These

include: NASA TechBriefs - premier monthly digest of NASA technology available for transfer, licensing and commercialization; NASA's Small Business Innovation Research (SBIR) & Small Business Technology Transfer (STTR) programs; NASA Scientific & Technical Information - a collected set of facts, analyses, and conclusions resulting from scientific, technical, and related engineering research and development efforts, both basic and applied; and NASA TechTracS - an access to NASA's technology inventory and numerous examples of the successful transfer and commercialization of NASA-sponsored technology. Below is just one microgravity related technology development and commercialization project lead by Dr. Rafat Ansari, out of 864 NASA success stories recently published under NASA TechTracS. This information is also captured in the newest version of the NASA Technology Inventory which will be open to the public.

Compact Non-Contact Fiber-Optic Probe For Diagnosis Of Eye Diseases

Point of Contact

Dr. Rafat Ansari

Objective & Description

Dynamic light scattering (DLS) probe is proving to be a practical, noninvasive diagnostic tool that is useful for the early detection of ocular pathologies and for understanding the mechanism of cataract formation. In the long term, it may be possible to use DLS data obtained from the eye to predict diabetic status. In addition, a noninvasive diagnostic method of molecular evaluation would enable repeat measurements to gauge response to therapy. The NASA probe seems to hold particular promise for ocular diagnostic work. Dynamic light scattering (DLS), has the potential to diagnose cataracts at the molecular level. Recently, a new DLS fiber-optic probe was developed at the NASA Glenn Research Center at Lewis Field for non-contact, accurate, and extremely sensitive particle-sizing measurements in fluid dispersions and suspensions. This compact, portable, and rugged probe is free of optical alignment, offers point-and-shoot operation for various on-line field applications and challenging environments, and yet is extremely flexible in regards to sample container sizes, materials, and shapes. No external vibration isolation and no index matching are required. It can measure particles as small as 1 nm and as large as few micrometers in a wide concentration range from very dilute (water-like) dispersions to very turbid (milk-like) suspensions. It is safe and fast to use, since it only requires very low laser power (10 nW to 3 mW) with very short data acquisition times (2 to 10 sec).

The probe was originally developed for performing dynamic-light scattering measurements to determine transport properties of submicron particles suspended in fluids in microgravity under the Advanced Technology Development Program.

The new DLS probe has been applied to characterize protein solutions and protein crystallization processes in NASA's flight hardware, but it can be quickly adapted to the various state-of-the-art ophthalmic instruments (e.g., the slit-lamp and Scheimpflug imaging) presently in use at the National Eye Institute of the National Institutes of Health (NIH). This modification advances the cataract diagnostic process from mere visual and photographic observations to molecular level investigations. Detection of lens changes may enable the early identification of diabetes in the many millions of people worldwide, who have undiagnosed diabetes. DLS also detects and quantifies the early changes associated with diabetes in the vitreous (the fluid that occupies 80 percent of the volume of the eye).

Benefit

Approximately 16 million Americans have diabetes mellitus, which can severely impair eyesight by causing cataracts, diabetic retinopathy, and glaucoma. Cataracts are 1.6 times more common in people with diabetes than in those without diabetes, and cataract extraction is the only surgical treatment. In many cases, diabetes-related ocular pathologies go undiagnosed until visual function is compromised. This ongoing pilot project seeks to study the progression of diabetes in a unique animal model by monitoring changes in the lens with a safe, sensitive, dynamic light-scattering probe.

State-of-the-Art (including metrics)

Up till now, visual and photographic, either by slit-lamp bio-microscopy or Scheimpflug imaging observations were the state of the art, no other probe with these capabilities existed. This approach is at least three orders of magnitude better than that.

Milestones (and Status)

The described system is in clinical tests right now at the NIH. This initial testing is being done to see the reproducibility of the methodology and safety. So far ten patients have been seen with excellent results. None of the patients reported any ill effects or side effects. The next milestone will be in the screening of anti-cataract drugs. Final stage will be the Food and Drug Administration's (FDA) approval.

NASA MICROGRAVITY RESEARCH PROGRAM AND TECHNOLOGY EDUCATION

NASA's Human Exploration and Development of Space (HEDS) Enterprise, one of the NASA's five strategic enterprises, is charged with the mission of "opening the space frontier by exploring, using and enabling the development of space and expanding human experience into the far reaches of space". One of the goals of the HEDS enterprise is to strive to ensure that all the citizens of the world have the opportunity to "share the experience, the excitement of discovery and the benefits of human space flight". During the past four decades, as NASA has embarked upon a series of ambitious human space flight missions, generations of young people have been inspired to undertake careers in science, mathematics and engineering – benefiting both themselves and the world.

The commercial development of space, which also has as its basis the 1958 National Aeronautics and Space Act which states, "[NASA] shall seek and encourage, to the maximum extent possible, the fullest commercial use of space"⁽⁵⁾, continues to be an important part of NASA's mission. Terrestrial applications of technologies developed for space have saved lives, made possible technological breakthroughs and created countless jobs. The further commercial development of space promises to yield still more jobs, technologies and capabilities benefiting people the world over

Specific HEDS near-term (2000 – 2004) objectives particularly applicable to technology education include:

- (1) Use of the HEDS' unique mission to encourage K-12 teachers and students to improve science literacy and to help them incorporate science, mathematics, technology and engineering disciplines into course work.

- (2) Enable [educators and students at all levels, kindergarten through university] first-hand, interactive participation in both human and robotic exploration.
- (3) Work with college and university faculty and students in the conduct of HEDS research and technology for future exploration..

In a recent article in *Mechanical Engineering* NASA Administrator Daniel S. Goldin, then NASA chief technologist Samuel L. Venneri and Ahmed K. Noor, director of the University of Virginia's Center for Advanced Computational Technology at NASA Langley Research Center, describe NASA's current emphasis on virtual work environments, known as Intelligent Synthesis Environment (ISE) and Intelligent Systems (IS). The article states, "The overall goal of NASA's programs is to revolutionize scientific research and engineering processes by creating a distributed collaborative environment that will enable the linking of design teams and scientists from NASA, industry, and universities in the creation and operation of aerospace systems and in synthesizing their missions."⁽²⁾ The article further states that the contributions of NASA's ISE and IS can be "...incorporated into three categories of advanced learning environments – expert-led group learning, self-paced individual learning and collaborative learning..."⁽²⁾ These three learning environments are consistent with the pedagogical thought regarding K-12 instructional approaches, and lend themselves particularly well to the newly redefined field of technology education. Mr. Goldin's assertion that the "human instructors" envisioned in NASA's ISE and IS learning environments will, "...serve many roles, including inspiring, motivating, observing, evaluating, and steering the learners, both individually and in distributed teams."⁽²⁾ in fact describes today's technology educator. With the advent of the distributed learning environment made possible through Internet-based Web chats and information sharing, even the "distributed" design team is possible in today's K-12 technology classroom.

According to the "*Standards for Technological Literacy: Content for the Study of Technology*, developed by the International Technology Education Association (ITEA) and formally reviewed by the National Research Council, confusion exists about the definition of technology education. "The field of technology education has evolved over the past fifteen or twenty years from industrial arts programs, technology education is just beginning to establish a new identity that people outside the field recognize and understand. There is still widespread confusion about the differences between technology education and educational technology, which uses technology as a tool to enhance the teaching and learning process."⁽⁴⁾ Indeed, one of the primary purposes of the ITEA's technology education standards is to help clear up this confusion by building the case for technological literacy by setting forth precise outcomes. The standards defined by the ITEA do more than provide a checklist of technological facts, concepts and capabilities that should be mastered by students at particular grade levels, but rather provide the conceptual framework for how technology fits within the broad mission of education, and also describes the benefits of the study of technology for students. All of this is to further the goal of technological literacy, which is defined by the ITEA as "the ability of use, manage, assess and understand technology." Technology is defined as "the modification of the natural environment in order to satisfy perceived human needs and wants." The *Technology Content Standards* emphasize three basic elements:

- (1) design – the main approach by which engineers, designers and others in technological fields use to create solutions to problems;
- (2) development and production – the process by which a design is transformed into a finished product, resulting in a system, that is created to produce it; and
- (3) use and maintenance – the final technology element that ultimately determines a product's success or failure.

The specific twenty technology standards described in “*Standards for Technological Literacy: Content for the Study of Technology*”⁽⁴⁾ are shown in Table 1 below:

Table 1. Technology Content Standards

Students will acquire knowledge of and abilities to:	Students will acquire knowledge of:
The Nature of Technology	<ol style="list-style-type: none"> 1. The characteristics and scope of technology 2. The core concepts of technology. 3. The relationships among technologies and the connections between technology and other fields.
Technology and Society	<ol style="list-style-type: none"> 4. The cultural, societal, economic and political effects of technology 5. The effects of technology on the environment. 6. The role of society in the development and use of technology. 7. The influence of technology on history.
Design	<ol style="list-style-type: none"> 8. The attributes of design. 9. Engineering design. 10. The role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.
Abilities for a Technological World	<ol style="list-style-type: none"> 11. Apply the design process. 12. Use and maintain technological products and systems. 13. Assess the impact of products and systems.
The Designed World	<ol style="list-style-type: none"> 14. Medical technologies 15. Agricultural and related biotechnologies. 16. Energy and power technologies. 17. Information and communication technologies. 18. Transportation technologies. 19. Manufacturing technologies. 20. Construction technologies.

There is a clear connection between NASA’s long history of recognizing its responsibility to communicate the knowledge gained from its unique mission of space exploration and improving the nation’s science, mathematics and technology educational systems, and the Intelligent Synthesis Environment (ISE) described by Mr. Goldin. The goal of technology education, as stated by the ITEA is to “...produce students with a more conceptual understanding of technology and its place in society, who can thus grasp and evaluate new bits of technology that they might never have seen before.”⁽⁴⁾ There is a parallel between what the ITEA is striving to achieve through technology education in grades K-12 and the collaborative virtual environment NASA’s Administrator envisions for a high performing NASA/industry/academic workforce, in order to propel us into the next generation of space exploration.

One of the common elements of the NASA Intelligent Synthesis Environment and the ITEA technology education model is the use of “design teams” as an integral part of the learning process. The *Technology Content Standards* recognize that “one of the great benefits of learning about technology is also learning how “to do” technology, that is to carry out in the laboratory-classroom many of the processes that

underlie the development of technology in the real world.”⁽⁴⁾ Teachers are encouraged to provide the opportunity for students to work in teams not only when building models of design proposals, but also when identifying and defining a specific technology problems and in the early stages of brainstorming possible solutions and constraints to ideas.

NASA’s Microgravity Research Program, a part of the Human Exploration and Development of Space (HEDS) Enterprise, has undertaken several technology education projects. At the International Technology Education Association (ITEA) annual conference in Salt Lake City this year, a curriculum supplement targeting K-12 educators was released: *Microgravity: Earth and Space – An Educator’s Guide with Activities in Technology Education, Science and Mathematics*. This education product was developed by a team of technology educators, as a collaborative activity between NASA and the ITEA. The goal of the project was to produce a curriculum guide that offered ways to apply technology to the field of microgravity science using problem solving strategies, critical thinking skills and a design team approach. In short, to provide teachers with practical laboratory based activities that followed the model for problem solving defined in the ITEA’s *Technology Content Standards*.

Each technology activity in *Microgravity: Earth and Space – An Educator’s Guide with Activities in Technology Education, Science and Mathematics* presents a design brief that describes the problem to be solved. The goals and objectives of the problem are specific, but the problem solving and design process is open-ended, allowing for many designs, materials and solutions. Each design brief provides an example or an illustration to give teachers and students an idea of how the problem may have been approached by another student team. Clearly the approach to the curriculum guide is team oriented, similar to how NASA implements its own projects. The first activity in the guide suggests how to establish project teams in the K-12 laboratory-classroom and presents a sample proposal and materials budget. The activities in the microgravity technology education guide are grouped by grade levels K-2, 3-5, 6-8 and 9-12. There are seven activities, each highlighting a different microgravity-related technology:

- (1) Way to Grow (Grades K-2), Growing plants in a simulated microgravity environment
- (2) It’s Crystal Clear (Grades 3-5), Crystal growth glovebox activity
- (3) Bubbles Technology (Grades 6-8), Building and Using a fluid flow demonstrator
- (4) Sim Satellite (Grades 6-8), Simulating Work in Microgravity
- (5) Hold That Satellite (Grades 6-8), Simulating Work in Microgravity
- (6) A Drop in the Bucket (Grades 9-12), Microgravity Drop Tower Activity
- (7) A Drop in the Bucket (Grades 9-12), Drop Tower Experiments

CONCLUSIONS

Although there are many ways to reach and educate the public about the significance of space science, technology provides a new and very convincing avenue to do so. In this paper, we have discussed how we could use technology as a means to reach and educate the public through technology development, transfer, and commercialization activities, and the importance of the international technology education standards published by the International Technology Education Association (ITEA). We would like to share our experiences, gained while working with NASA’s Microgravity Technology Development and Transfer Program and the Microgravity Outreach Program, with our international colleagues. We believe that through international collaboration in space science and technology development, and continued work with the ITEA, we can effectively communicate to the public worldwide the benefits resulting from space research and strengthen international space outreach programs and activities.

REFERENCES

- (1) Clinton, W. J., A. Gore Jr., *Science in the National Interest*, Executive Office of the President, Office of Science and Technology, August 1994.
- (2) Goldin, D.S., Venneri, S.L., Noor, A.K., *Mechanical Engineering*, **vol. 121, no. 11**, November 1999 pp. 61-66.
- (3) Rensberger, B., Fundamental Research at Risk, *The Washington Post*, sec. A, December 27, 1994.
- (4) Technology for All Americans Project. (2000). *Standards for technological literacy: Content for the study of technology*. Reston, VA: International Technology Education Association. pp. 3-15.
- (5) The National Aeronautics and Space Act of 1958, Public Law 335-568